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Optimizing Greenhouse Corn Production: What Is the Best Irrigation Strategy?

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Purdue Methods:

Optimizing Greenhouse Corn Production

What is the best irrigation strategy?

Greenhouse-grown corn can be a challenging crop to irrigate. It usually involves genetic lines of differing vigor, so pots don't dry at same rate. This means the watering can't be automated and groups of pots must be watered according to need with a hose. Large nursery pots considered necessary for growth to maturity take a lot of time to irrigate. Recommendations usually call for increasing irrigation frequency as plant grows, increasing again during pollination period, and decreasing as seed ripens. A skilled grower can learn these techniques and the effect the season or weather has upon them. But often the size of a corn planting requires the effort of a team of waterers, each making their own subjective decisions. Poor irrigation practice has been blamed for calcium deficiency in seedlings, micronutrient deficiency in young plants, root rots, poor pollination, and even seed rots.

Our goal was to design a growing system for corn using automated drip irrigation to apply a general purpose fertilizer solution (see Figures 1-3). No drought stress or nutrient stresses would occur, maximizing growth. We also wanted the irrigation method to be easy so it could be adopted by any facility, no matter what the level of technology.

The system we propose uses a very porous medium consisting of calcined clay granules. For simplicity, in this report we'll refer to the larger-sized calcined clay granules by the trade name Turface and the smaller size granules by Profile (no endorsement intended). For this system, we recommend drip irrigation activated several times daily. The idea was first validated by the results of Experiment 1 (see Materials and Methodology) and refined in Experiment 4. In that experiment, our sense of the best frequency for Turface calcined clay was every 2 hours or twelve times daily; for Profile calcined clay, every 8 hours or three times daily. This was based on "gut feel" from watching the water status of the plants and media—there were no statistical differences in seed yield or days to pollination between any of the treatments. Yield means ranged from a 420-552 seeds/plant. A 48-hour frequency treatment did not set any seed so was not analyzed. One goal was met: We were able to use the same irrigation program through all stages of plant growth and maturity, seed to harvest.

What was the irrigation duration?

Using 20-cm diameter pots filled with calcined clay, the duration was two minutes. This was more than enough to saturate the pots. This was more than needed, in fact, but was the lowest

setting on the battery-operated irrigation timer that we suggest could be used by facilities without advanced controls.

For facilities with advanced control systems, we recommend two 30-second irrigations with a pause of five minutes in between. The pause allows for some lateral movement of the water. This one-minute duration reduces water usage by half over the battery-operated timer. Further reduction can be achieved by only allowing the irrigation to activate during daylight hours, for example 6:00AM to 8:00PM. This programming results in a total daily irrigation time of 8 minutes, a mere one-third of the 24 minutes with the battery-operated timer. But keep in mind that our proposed system will not save water over traditional corn production.

What about sub-irrigation?

Sub-irrigation means allowing water to be taken up from the bottom of the pot by capillary action. Water is applied in a tray and then drained once the pot is saturated, usually after just a few minutes. It can be an effective method of watering corn. We know of at least two research facilities that use it, and several of our smaller studies were carried out this way. We believe that none of our recommendations need to be changed if sub-irrigation is be used, except that it may be wise to flush media of accumulated fertilizer salts. Every 3-4 weeks, water abundantly with a hose using clear water, repeat one hour later. Figure 4 shows a method of using a drip irrigation system to fill up the sub-irrigation tray, allowing for simple automation.

Sub-irrigation systems make it easier to collect and re-use fertilizer solution. One research facility reported no seed yield differences between plants where fertilizer solution was re-used for three days and plants where new fertilizer solution used at each irrigation (personal communication). This reduced waste and nitrogen runoff into drains.

Creating an artificial perched water table

In this porous medium, water could be constantly held in the bottom of the pot, creating an artificial perched water table, without damage to the plants. There was even some indication of a benefit in number of tillers formed—usually a sign of plant vigor—with Turface in Experiment 14 (see Table 1), but these studies were too small to analyze statistically.

The artificial perched water table may also be insurance against irrigation system failures. At the very least we showed the technique does no harm. Keeping a medium this wet goes against conventional wisdom, especially with corn. It would most likely result in root rots using traditional soil mixes. We suggest it works with calcined clay because plenty of open pore space is available for roots above the water table. Or frequent irrigation may be replacing dissolved oxygen in the perched water table.

It's difficult to do this technique on a large scale planting, so we don't recommend it as a general practice. Either you need a modified pot, or a saucer that slips all the way down inside the pot without gaps. If you use a tray or saucer outside of the pot like we did in Experiment 14, controlling algae is difficult. Also keep in mind that the shorter the pot, the less of a perched water table you can have: a perched water table inhibited germination in Profile grown plants when we reduced the pot size in Experiment 12. But the technique is worth considering in calcined clay for the absolute ease of watering: One graduate student grew a few corn plants in a tray that held 3 cm of water. He simply kept this tray full and grew healthy plants—no tricky decision-making or watering technique.

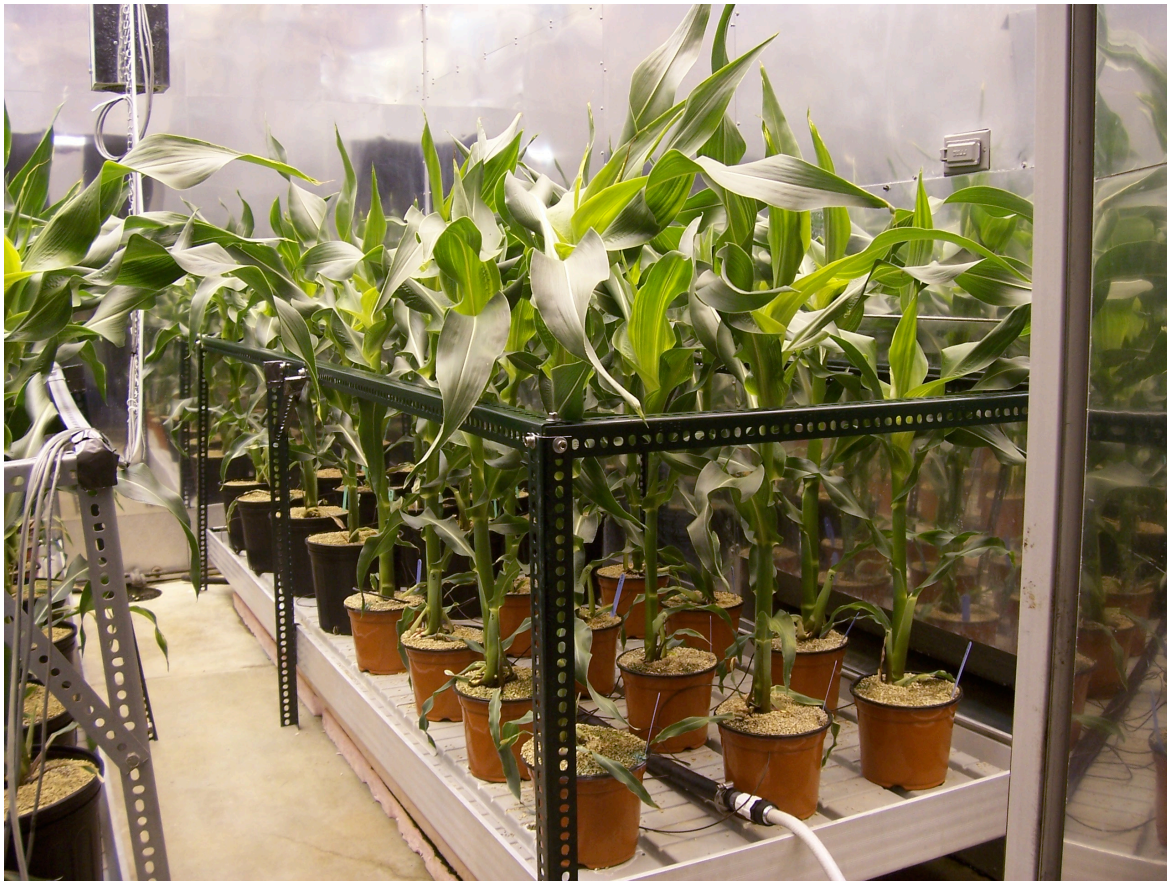


Figure 1. Healthy corn plants grown in a growth chamber using the prescribed irrigation method.



Figure 2. Left: Irrigation drip ring. Right: Irrigation drip emitter.



Figure 3. Battery irrigation timer and portable fertilizer injector used in some of our studies to replicate low technology.

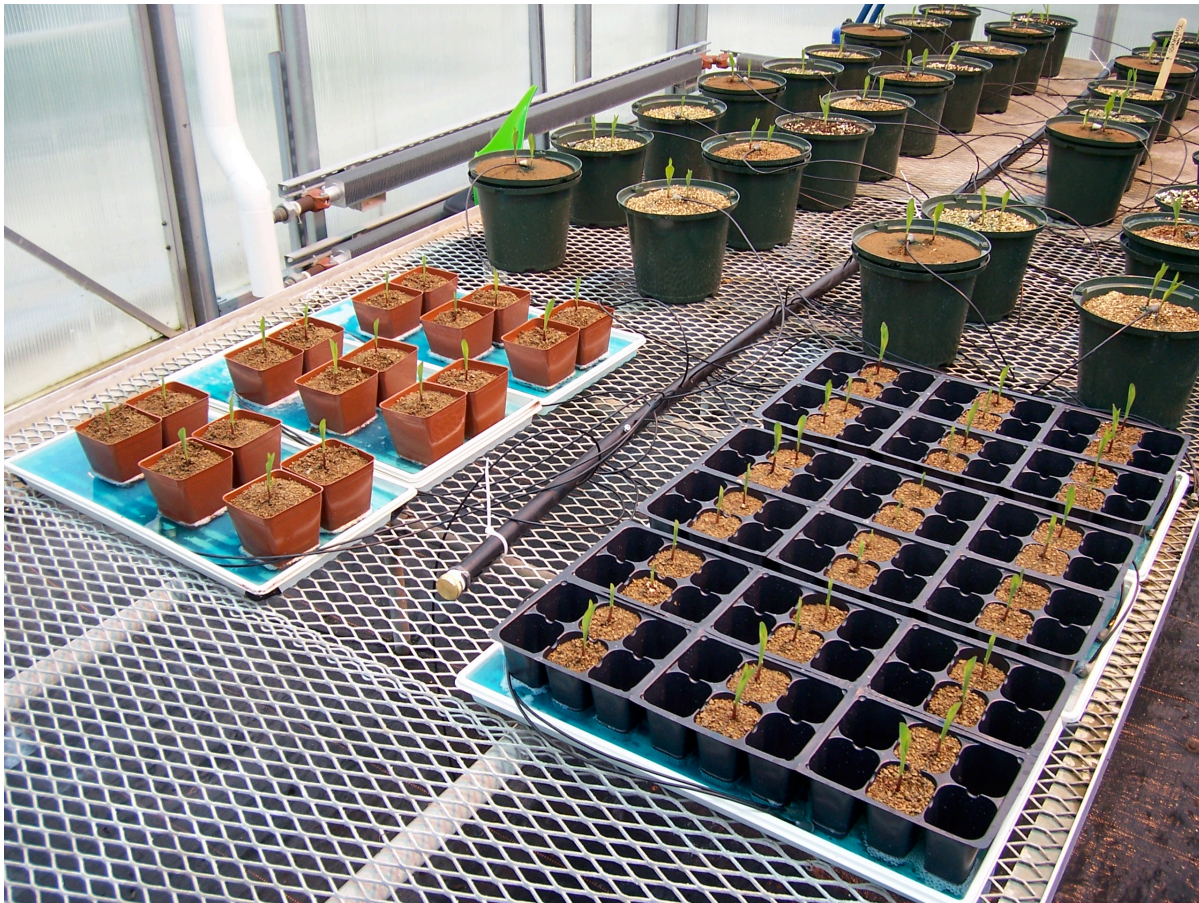


Figure 4. Foreground: Sub-irrigation using trays filled by automated drip irrigation.



Figure 5. Tillers arising from crown.

Table 1. Height and tiller number of 35-day old corn plants with and without artificial perched water tables in Experiment 14.

Treatment	Height (cm)	Tillers per plant*
Profile, no perched table	132	1.0
Profile, 2 cm perched table	133	2.0
Profile, 3 cm perched table	136	1.0
Turf, no perched table	124	0.25
Turf, 2 cm perched table	132	1.0
Turf, 3 cm perched table	121	1.5

*Secondary shoots arising from crown, usually an indicator of plant vigor.